

# AI Planning

## Exercise Sheet 12

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 Students: Axel Perschmann, Tarek Saier

### Exercise 12.1

$$\begin{aligned}
 D_0^{bwd} &:= \{\gamma\} && // \text{per definition} \\
 D_1^{bwd} &:= \{\gamma, o_1\} && // a \text{ is precondition, } b \text{ is an effect in any case} \\
 D_2^{bwd} &:= \{\gamma, o_1, o_2\} && // a \text{ is an effect in any case} \\
 D_3^{bwd} &:= \{\gamma, o_1, o_2, o_3\} && // \neg a \wedge b \text{ is an effect in any case} \\
 \delta_G^{bwd}(I') &= 3
 \end{aligned}$$

### Exercise 12.2

Definitions:

$$\begin{aligned}
 \text{img}_o(s) &= \{s' \in S \mid s \xrightarrow{o} s'\} \\
 \text{wpreimg}_o(T) &= \bigcup_{s \in T} \{s \in S \mid s \xrightarrow{o} s'\} \\
 \text{spreimg}_o(T) &= \{s \in S \mid \exists s' \in T : s \xrightarrow{o} s' \wedge \text{img}_o(s) \subseteq T\}
 \end{aligned}$$

The definition of a weak preimage can be reformulated as follows:

$$\text{wpreimg}_o(T) = \{s \in S \mid \exists s' \in T : s \xrightarrow{o} s'\}$$

Since in the given transition system an operator leads from a state in which it is applicable to *exactly one* state we can further reformulate:

$$\text{wpreimg}_o(T) = \{s \in S \mid s \xrightarrow{o} s'\}$$

For the strong preimage, performing the same step we get:

$$\text{spreimg}_o(T) = \{s \in S \mid s \xrightarrow{o} s' \wedge \text{img}_o(s) \subseteq T\}$$

Again, since there is only one state an operator can lead to from a given state,  $s \xrightarrow{o} s'$  implies  $\text{img}_o(s) \subseteq T$ . We therefore get:

$$\begin{aligned}
 \text{spreimg}_o(T) &= \{s \in S \mid s \xrightarrow{o} s' \wedge \top\} \\
 &= \{s \in S \mid s \xrightarrow{o} s'\} \\
 &= \text{wpreimg}_o(T)
 \end{aligned}$$

### Exercise 12.3

(a)

Nondeterministic planning task:  $\Pi = \langle V, I, O, \gamma \rangle$ , where

$$V = \{L_1, L_2, R_1, R_2\} \in \{e, x, y\}$$

$$I = \{L_1 \rightarrow e, L_2 \rightarrow e, R_1 \rightarrow e, R_2 \rightarrow e\}$$

$$O = \{o_L, o_R\}$$

$$\gamma = \{(L_1 = x \wedge L_2 = x) \vee (R_1 = x \wedge R_2 = x) \vee (L_1 = x \wedge R_1 = x) \vee (L_2 = x \wedge R_2 = x) \vee (L_1 = x \wedge R_2 = x) \vee (L_2 = x \wedge R_1 = x)\}, \text{ where}$$

$$o_L = \langle L_1 = e \vee L_2 = e, (L_1 = e \rightarrow L_1 = x) \wedge (\neg L_1 = e \rightarrow L_2 = x) \rangle$$

$$o_R = \langle R_1 = e \vee R_2 = e, (R_1 = e \rightarrow R_1 = x) \wedge (\neg R_1 = e \rightarrow R_2 = x) \rangle$$

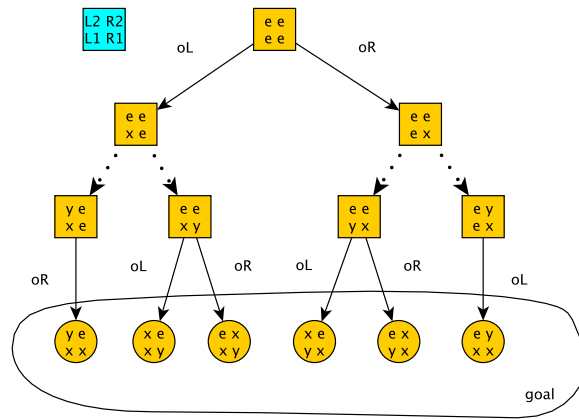


Figure 1: Nondeterministic Transition Graph for 2x2 TicTacToe

(b)

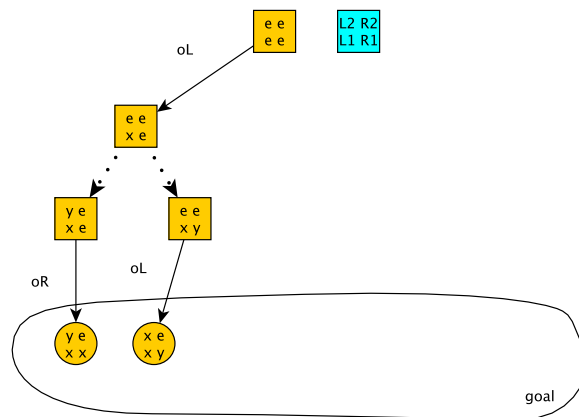


Figure 2: SolutionGraph for 2x2 TicTacToe provided by Progression Search